EAI ELECTRONIC ASSOCIATES INC. ■ LONG BRANCH, NEW JERSEY

AUGUST 1966

EAI 680 ANALOG/HYBRID COMPUTING SYSTEM

SPECIFICATIONS

ANALOG COMPONENTS

I SYSTEM SPECIFICATIONS

1. Computer Power Requirements

Voltage	110/120 VAC - 220/240 VAC
Frequency	50/60 CPS
Power	1 KW, Maximum

2. Mechanical

Size With DFG Pedestal	61 Inches High, 58 Inches Wide, 46-1/2 Inches Deep
Size Less DFG Pedestal	61 Inches High, 58 Inches Wide, 32 Inches Deep
Weight	2000 Pounds (Fully Expanded)

3. Reference System

Output Voltage	+10V and -10 VDC
Output Current	1 Amp Each Output
Balance	Better than 0.005%

4. Repetitive Operation Timers

Number of Time Periods	3
Timing Standard	1 MC Crystal
Range Each Timer	10 μSec to 99.9 Sec

II OPERATIONAL AMPLIFIER SPECIFICATIONS

(Specifications are given for components operating in the computer with measurements being made at the console pre-patch panel.)

1. General

Circuitry	All Solid State
Chopper	Electro-Mechanical
Drive	60 HZ
Output Voltage	±10V, Minimum

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Output Current		30 MA, Minimum
Total DC Open Loop Voltage Gain		3×10^7, Minimum
Velocity Limit		25×10^6/Sec, Typical

2. Summer

Number of X 1 Inputs		3
Number of X 10 Inputs		3
Standard Feedback Resistor		100K Ohms
Resistor Accuracy	Feedback Resistor	±0.005%
	Ratio	±0.005%
Resistor Ratio Stability (3 Years)		±0.005%
Crosstalk at 10 KHZ		80 db Down, Minimum
Frequency Response Characteristics *as a 100K/100K Inverter* bandwidth (3 db Down 20V PP Input)		500 KHZ, Minimum
Peaking		0.5 db, Maximum
Phase Shift	at 1 KHZ	0.08°, Maximum
	at 10 KHZ	0.8°, Maximum
Amplitude Error	at 1 KHZ	0.05%, Maximum
	at 10 KHZ	0.5%, Maximum
Total Instantaneous Dynamic Error	at 1 KC	0.15%, Maximum
Offset Voltage (Referred to S.J.)		20 μVolts, Maximum
DC Offset Temperature Drift		1 μVolts/°F, Maximum
Noise (0-79 KC) SCI Filter		1 MV PP, Maximum
Noise (0-790 KC) SCI Filter		2.0 MV PP, Maximum
Stability With Capacitive Loading:		
	On S.J.	0.1 μfd, Minimum
	On Output	0.1 μfd, Minimum
	Simultaneously	0.03 μfd, Minimum

III INTEGRATOR SPECIFICATIONS

Number of X 1 Inputs		4
Number of X 10 Inputs		3
Number of IC Inputs		1
Logic Control Input Levels		+5V and 0V
Capacitor Sizes		10, 1, 0.01, 0.001 μfd
Capacitor Accuracy		10 μfd 0.01%; All Others Adjustable
Resistor Accuracy	Feedback Resistor	±0.005%
	Ratio	±0.005%
Switch Time (IC to OP, or OP to IC)		1 μSec, Maximum
Switch Time (OP to H, or H to OP)		2 MS, Maximum
Differential Switching Time (Hold Relay)		1 MS, Maximum
Drift	in Hold	10 μVolts/Sec, Maximum
	in Operate Gain 1 Grounded	20 μVolts/Sec, Maximum
Reset Time (20V)	10.0 μfd	3 MS/Maximum
	0.01 μfd	50 μSec/Maximum

IV MULTIPLIER SPECIFICATIONS

Circuitry	Bi-Polar, All Solid State
Modes of Operation	Multiply, Divide, Dual Square, Dual Square Root
Feedback Resistor, Used With Output Amp	10K
Output Voltage Range (With Amplifier)	±10V
Adjustment Location	Side of Tray
Adjustment Cycle (Nominal)	6 Months
Overload Indication	Operates When: $(X + Y) > 20$
Static Error $-(X + Y) \leq 20V$	±0.025% of Full Scale (±5 MV), Maximum ±0.015% of Full Scale (±3 MV), Typical
Either Input Zero	±0.02% of Full Scale (±4 MV), Maximum
Both Inputs Zero	±0.0025% of Full Scale (±0.5 MV), Maximum
Dynamic Characteristics	
Bandwidth (3 db Down; Y = 10 VDC; X = 20V PP)	500 KC, Minimum
Phase Shift — 1 KHZ	0.2°, Maximum
Phase Shift — 10 KHZ	2.0°, Maximum
Total Instantaneous Dynamic Error — 1 KHZ	40 MV, Maximum
Total Instantaneous Dynamic Error — 10 KHZ	300 MV, Maximum
Peaking	1 db, Maximum
Noise, 790 KC SCI Filter	3 MV PP, Maximum
Drift, With Temperature	0.002% of Full Scale (0.4 MV/°F), Maximum
Input Impedance	1.6K

V TRACK STORE SPECIFICATIONS

Number of Modes	3 (Track, Store, IC)
Logic Control	+5V and 0V
Switching Time	1 μSec, Maximum
Total Instantaneous Dynamic Tracking Error at 200 HZ	0.05%, Maximum
Total Instantaneous Dynamic Tracking Error at 1 KHZ	0.25%, Maximum
Total Instantaneous Dynamic Tracking Error at 10 KHZ	2.50%, Maximum
Drift in Store	100 μVolts/Sec, Maximum
Reset Time (20V to 0.1%)	40 μSec, Maximum

VI COMPARATOR SPECIFICATIONS

Circuitry	All Solid State
Number of Inputs	3
Input Voltage Range (Nominal)	±12V

Input Impedance	10K
Output Voltage	0 or +5V (Logic Level) and Complement Synchronized With Central Timing Reference
Control	Manual Pushbuttons, Plus Latching Input
Sensitivity	±5 MV, Maximum
Switching Time	1 μSec, Plus 1 Clock Period
Indication	Individual Indicator for Each Comparator

VII DIGITALLY CONTROLLED ANALOG SWITCH

Circuitry	All Solid State
Switch Control — "ON" state	+5V (Logic Level)
Switch Control — "OFF" state	0V (Logic Level)
Input Voltage Range	±10V
Analog Input Impedance	10K
Static Error	0.015%, Maximum
Propagation Time	1 μSec, Maximum

VIII SINE-COSINE GENERATOR

Circuitry	All Solid State
Input Scale Factor	20°/Volt
Input Range	±9V, Maximum
Output for Plus Input	-10 Sine θ, or ±10 Cos θ
Adjustment Location	Side of Tray
Adjustment Cycle (Nominal)	Six Months
Static Error, for: $-5V \leq E_o \leq +5V$	±3 MV, Maximum
$-10V \leq E_o \leq -5V$	±6 MV, Maximum
$+5V \leq E_o \leq +10V$	±6 MV, Maximum
0V Input	±2 MV, Maximum
Bandwidth, to ±45°	200 KHZ
to ±180° (SCI Conditions)	80 KHZ
Phase Shift — at 1 KHZ	0.5°, Maximum
Phase Shift — at 10 KHZ	1.0°, Maximum
Noise, 790 KC SCI Filter	3 MV PP, Maximum
Temperature Drift	0.8 MV/°F, Maximum
Input Impedance	3,333Ω

IX DUAL LOG X FUNCTION GENERATOR (One Plus Unit, One Minus Unit)

Circuitry	All Solid State
Scale Factor	$E_o = LOG_e (\frac{Ein}{10})$
Input Range — Plus Unit	0 to +10V
Input Range — Minus Unit	0 to - 10V
Static Error — $0 \leq E_o \leq 4.6052$	±6 MV, Maximum

Drift With Temperature Change (70°F to 85°F).	0.5 MV/°F, Typical
Bandwidth	300 KHZ, Minimum
Phase Shift	0.8°, Maximum
Peaking	1 db, Maximum
Noise, 10V Input, 790 KC, SCI Filter	3 MV PP, Maximum
Noise, 0.1V Input, 790 KC, SCI Filter	10 MV PP, Maximum
Input Impedance	1,200Ω

X VARIABLE DIODE FUNCTION GENERATOR

Circuitry	All Solid State
Input Voltage Range	±10V
Output Voltage Range	±10V
Number of Segments	10, or Paired for 20
Parallax	±10V
Slope Selection Switch.. Minimum Position	1V/V
Maximum Position	32V/V
Adjustments Breakpoint and Slope	Ten-turn Potentiometers
Frequency Response Characteristics (Employing SCI Measurement Techniques for a 10-Segment Function)	
Bandwidth (3 db Down for 20V PP Input)	100 KHZ, Minimum
Bandwidth (3 db Down for 2V PP Input)	150 KHZ, Minimum
Peaking	1 db, Maximum
Total Instantaneous Dynamic Error: at 100 HZ	0.05% Full Scale, Maximum
at 1 KHZ	0.5% Full Scale, Maximum
Phase Shift at 100 HZ	0.03°, Maximum
at 1 KHZ	0.3° , Maximum
Noise, SCI 10-Segment, 790 KC SCI Filter	6 MV PP, Maximum
Temperature Drift (SCI)	1 MV/°F, Maximum

XI POTENTIOMETERS, STANDARD

Resistance	5K Ohms
End Resistance	1Ω (0.02%)
Resolution	0.01%, Minimum
Setting Time (Servo Pots)	0.5 Sec Average 1.0 Sec, Maximum
Setting Error	0.01%, Maximum
Phase Shift at 1 KC (Gain 1 Load Any Setting from 0.1 to 1.0)	0.4°, Maximum
Overload Protection	Current Limiting (No Fuse)

XII POTENTIOMETERS, PHASE-COMPENSATED

Resistance	5K Ohms
End Resistance	1Ω (0.02%)

Resolution	0.01%, Minimum
Setting Time (Servo Pots)	0.5 Sec, Average 1 Sec, Maximum
Setting Error	0.01%, Maximum
Phase Shift at 1 KC (Gain 1 Load Any Setting from 0.1 to 1.0)	0.1°, Maximum
Overload Protection	Current Limiting (No Fuse)

EAI 680 SCIENTIFIC COMPUTING SYSTEM

PRELIMINARY SPECIFICATIONS

MAXIMUM EQUIPMENT COMPLEMENT:

Analog Equipment:

Total Amplifiers	156
Combination Amplifiers	30
Summer Amplifiers	24
Inverter Amplifiers	60
High-Gain Amplifiers	24
Committed DFG Amplifiers	18
Potentiometers: Servo 5K	120
Manual 5K	12
Multipliers	24
Variable DFG	18
Fixed DFG	18
Track Store	12
Comparators	24
Function Relays D.P.D.T.	24
Limiters: Variable	12
Zero	12
D/A Switches	24

Logic Equipment:

General-Purpose Register (4-bit)	6
AND Gate Tray (6 gates/tray)	6
Mono-Dif Tray (3 each/tray)	2
BCD Counter Tray (2 decade each)	3
Integ-TS Control Tray	6
Logic Interface Tray	6
Main Mode Control Tray	1

AMPLIFIER SPECIFICATIONS:

Voltage Range	±10V min.
Output current (short circuit proof)	30 ma min.
Open Loop D.C. gain	3×10^7 min.
Velocity Limit	25×10^6 V/sec typical.
Bandwidth (100K/100K; 20V PP input)	500 KC min.
Phase Shift (1KC, 100K/100K; 20V PP)	.05° typical.
Gain Error (1KC, 100K/100K)	.1% max.
Offset at summing junction (100K/100K)	20 uv max.
Noise	1 mv. P.P. max.

VARIABLE LIMITER SPECIFICATIONS:

Limit Range plus limit control	+0.5V to +10V.
minus limit control	−0.5V to −10V.
Limit Slope	5mv/volt input

INTEGRATOR SPECIFICATIONS:

Capacitor sizes	10, 1, .01, .001 ufd
Switch time Ic to OP or OP to Ic)	1 μsec
Drift (in hold 10 ufd)	5 uv/sec typical
	10 uv/sec max.
Logic control signal: voltage	+5V
current	−2 ma max. at "0" Volt
Reset Time: 10 ufd	3 ms max.
.01 ufd	50 μsec

MULTIPLIER SPECIFICATIONS:

Static Error ($\|x\| + \|y\| < 20V$)	.025% max.
	.015% typ.
(either input zero)	.02% max.
(both inputs zero)	.0025% max.
Total Instantaneous Dynamic Error (1KC)	.2% max.
Bandwidth (Y=10 Vdc x=1VP.P.)	500 KC Min.
Phase Shift (1KC)	.2° max.

SERVO SET POT SPECIFICATIONS:

Resistance Value	5 K ohms
Setting Time	1 sec max.
Setting Accuracy	.01%

TRACK STORE SPECIFICATIONS:

Track Time Constant	300 nanoseconds
Drift in Store	100 uv/sec max.

COMPARATOR SPECIFICATIONS:

Switching Sensitivity	2 mv max.
Operate Time	1 μsec max.
Output Logic Signal	+5 volts

D/A SWITCH SPECIFICATIONS:

Input Resistors (2 inputs)	10K
Output—connect to amplifier summing junction	
Switching Time	1 μsec max.

LOGIC ELEMENTS SPECIFICATIONS:

Logic Level: binary "0"	0V
binary "1"	+5V
Input Current: binary "0"	+2 ma
binary "1"	0 ma
Output Current: binary "0" (current sinking capacity)	−30 ma
binary "1" (current driving capacity)	+15 ma

These are preliminary specifications and are subject to change without notice.

EAI 680 Scientific Computing System

an economical, high-performance hybrid computer

EAI®
ELECTRONIC ASSOCIATES, INC.,

EAI® 680

A HYBRID COMPUTER TO GROW WITH

The EAI 680 Scientific Computing System is an economical, high-performance, medium-size, analog/hybrid computing system. With a design that results from an extensive study of scientific computation requirements of over 1,000 EAI customers, this computer sets a new standard for economical, analog/hybrid simulation. Using a ±10 volt reference level, it combines for the first time the outstanding dynamic performance of EAI 10 volt computers with the high static accuracy that previously has been available only in slower and more expensive, large-scale 100 volt systems.

The EAI 680 Scientific Computing System is a computer to grow with . . . the user can start with an inexpensive basic system that includes analog components and parallel digital logic elements; then, he can expand the system to 156 analog amplifiers and an extensive complement of non-linear and digital logic devices; finally, he can add a fast, stored-program digital computer – for full hybrid power.

The basic system is completely pre-wired to accept the full complement of plug-in computing components. Also, the basic system includes complete control and analog display capability. Thus, the EAI 680 can be expanded economically to keep pace with the user's requirements and ability to formulate more sophisticated models for simulation.

APPLICATIONS

During the early stages of the EAI 680 development, a team of applications specialists from the EAI Research & Computation Division made an extensive survey of significant analog and hybrid problems. They analyzed in depth hundreds of problems solved at EAI Computation Centers as well as the equipment used in the solution of these problems. This study had a strong influence on the development of the EAI 680 system. Major applications were considered on the basis of a "paper" system design before the actual development of hardware for the EAI 680 was begun.

Applications in the Process Industries

Problems associated with the Process Industries were studied by the team of EAI applications specialists. Consequently, the EAI 680 Scientific Computing System has been designed to handle applications such as: the simulation and design of both analog and digital process control systems; studies of complex reactor dynamics; design of heat exchangers; parameter optimization, such as in non-linear chemical kinetics studies; simulations involving large, fixed or variable time delays; automatic data fitting; staged system simulations; simulation of processes and control systems for operator training; and, the system design for nuclear reactor/heat exchange and control. The compact EAI 680 with its rugged, welded steel frame construction, low power requirements, zero temperature coefficient capacitors, and temperature compensated non-linear equipment is ideal for operation in normal laboratory environments.

The University and the EAI 680

The new EAI 680 hybrid system will play a significant role in university research and teaching programs. Many university science faculties are planning to make modern, analog/digital machine combinations available to students on an undergraduate level. The EAI 680 Scientific Computing System is well-suited for this; it is a powerful hybrid computer — yet available on a university budget.

The role of the modern, analog/hybrid computer in the university is three-fold: first, to provide a tool for instructing students in the programming and design of a modern, scientific computer; second, to demonstrate to the students the dynamic behavior of physical systems — hybrid simulation is uniquely capable in aiding student understanding of process and system performance; third, to enable the solution of significant problems in graduate and faculty research.

A professor in a leading engineering school recently stated that hybrid/analog computation can help to produce an enlightened group of graduates who will appreciate that computers are more than just sophisticated calculators. Hybrid computation is a powerful tool and a key to the future; the students must be made familiar with its applications, he concluded.

EAI 680 in the Life Sciences

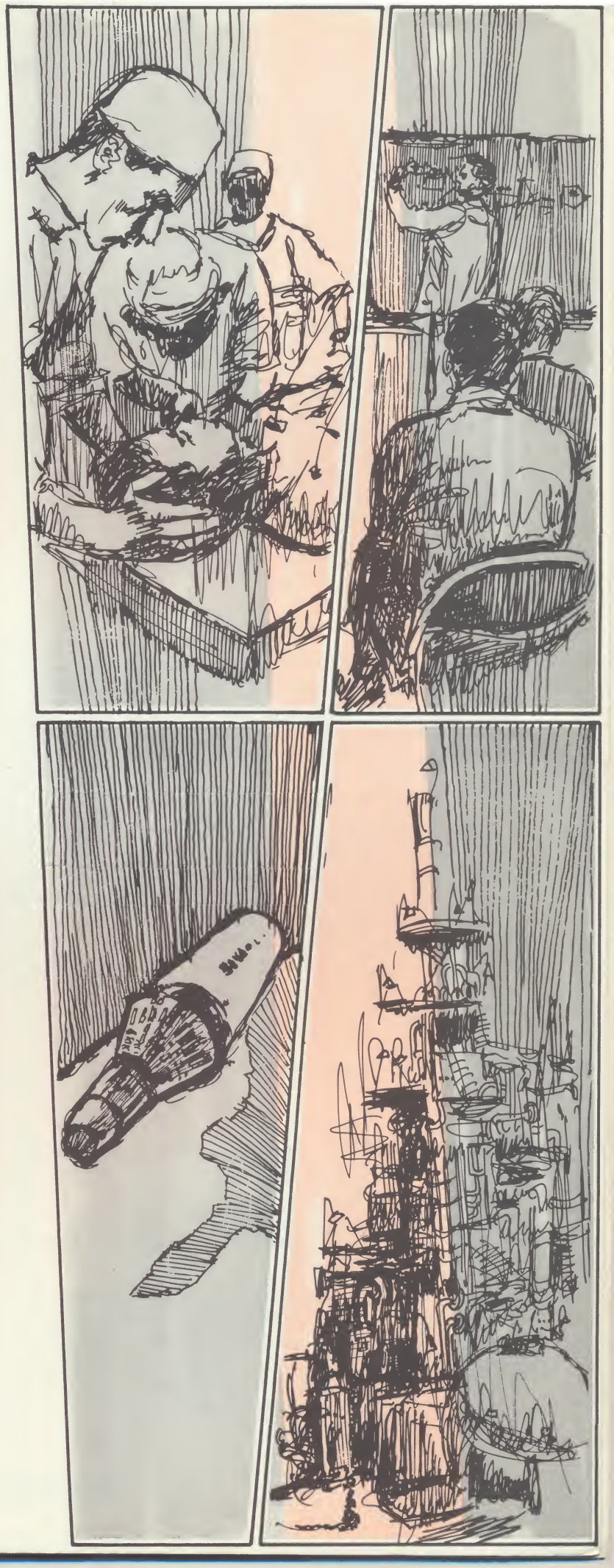
The life science requirements — on-line signal processing and powerful data reduction — are required in EKG and EEG studies and were carefully considered in the design of the EAI 680. This new hybrid system is well-suited to solving these problems, and to the simulation of a wide variety of physiological systems, such as circulatory systems which require the solution of partial differential equations. Other applications in the life science area include pattern recognition studies. These involve learning systems and general training where the observer of the simulation receives a unique insight into the dynamics of visible systems. Potential users in the life sciences area may also take advantage of regularly scheduled EAI courses on bio-engineering applications of analog and hybrid simulation.

The EAI 680 for Aerospace Simulation

The analog/hybrid computer is a necessity in the simulation for design of all aircraft, missiles, and space vehicles. The EAI 680 Scientific Computing System is of interest to the aerospace engineer because of its considerable computing power-per-dollar. It can be adapted to operate with existing one-hundred volt equipment and operates at comparable accuracies. Further, its ultra high-speed computing capability and wide bandwidth make it ideal as a high-speed expansion to existing slower large-scale computers.

General Industry Applications

EAI application surveys indicate that the EAI 680 computer offers definite advantages in many other application areas. The studies that were made include control system design, heat transfer problems, statistical analysis, optimization studies, and learning and recognition problems.



HYBRID CAPABILITY

The EAI 680 is an economical, operator-oriented computing system that has been expressly designed as a hybrid computer. The full hybrid capabilities of this computer are reflected in its solid-state addressing and readout system, automatically adjustable potentiometers, extensive parallel digital logic, high-speed capability, complete analog-digital patch panel termination, and system expansion facility.

Addressing and Readout

An electronic solid-state addressing and readout system enables the digital computer to address and read out any analog component. Designed to accept an entry, byte-by-byte, the system is provided with the capability for handling normal digital computer data.

Automatically Adjustable Potentiometers

In many hybrid problems, analog potentiometers are set to coefficients that are calculated by the digital computer. "Servo-set" potentiometers required for hybrid computation form a part of the standard equipment complement of the EAI 680 Scientific Computing System. These potentiometers can be read out or set up by the digital computer using the electronic addressing system. The desired potentiometer coefficient is transferred in digital form from the digital computer to a built-in digital-to-analog converter. The latter converts the digital information to an analog voltage that in turn is used to set the potentiometer addressed.

Logic

Uncommitted parallel digital logic has been made available in the EAI 680 for decision making and control requirements. When operating with the digital computer, the logic can be either synchronized with an internal clock system or slaved to an external signal from the digital machine.

With logic level control, the mode and time scales of all integrators in the computer can be controlled individually from the analog console or by the digital computer. This important feature facilitates the analog and hybrid solution of iterative type problems, such as the solution of partial differential equations.

High-Speed Capability

Efficient hybrid operations rely heavily on the high-speed capabilities of the system's analog components. Analog components available with the EAI 680 feature wide bandwidth and high static accuracy. The system's operational amplifiers operate with negligible velocity limiting within their 500 kc bandwidth. Electronic mode control, with extremely fast switching and reset times, permits the control of individual integrators.

Time scale changes of 1,000 to 1 and 10,000 to 1 permit compressed time scale, repetitive and iterative operations. Ultra-fast signal tracking (in under 1 microsecond) combined with low-drift storage is provided by the system's track/store networks. Many other components — such as high-speed, digital/analog electronic switches — have been included as well.

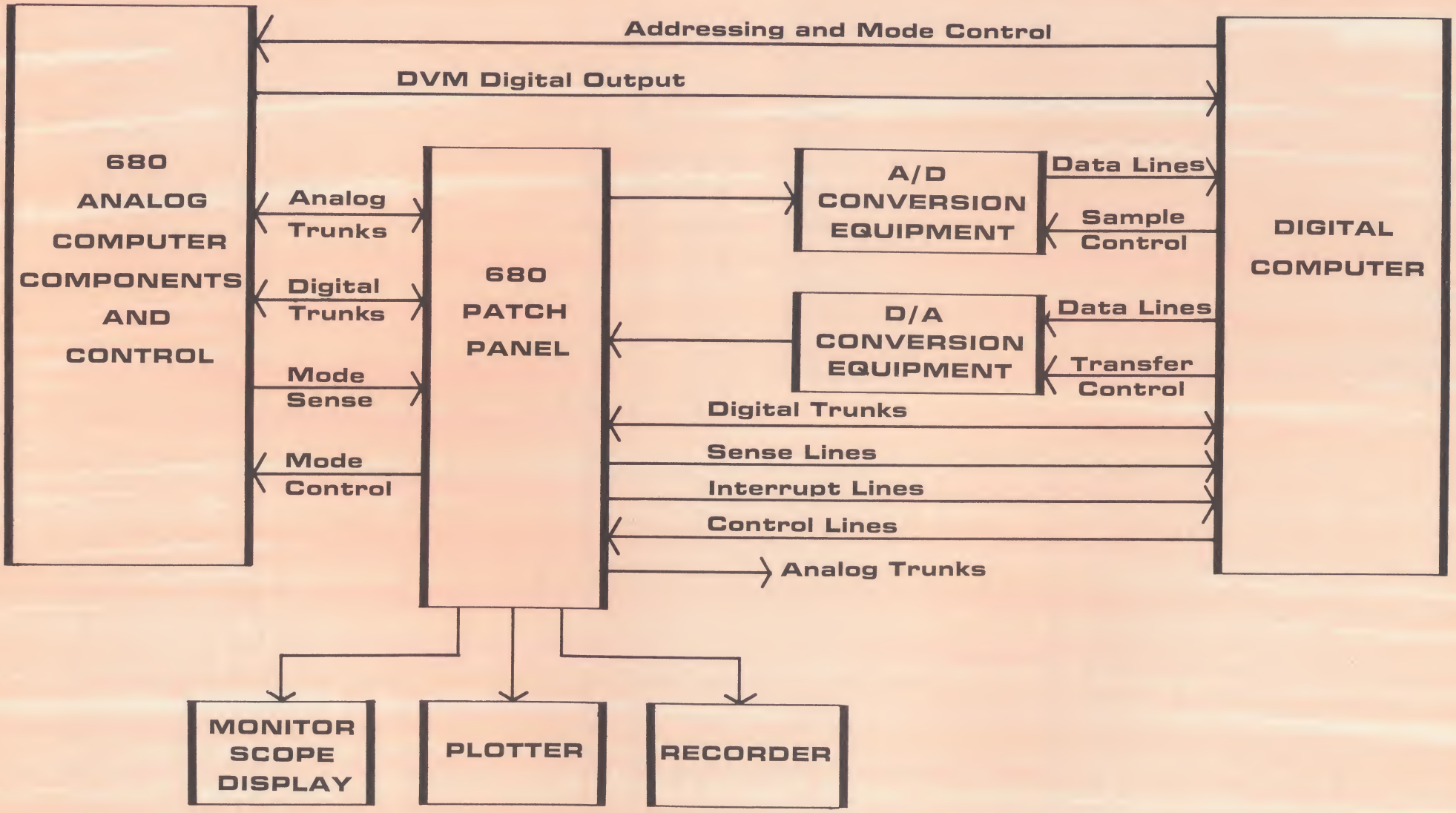
Variables can be multiplied with high accuracy at speeds in excess of one kilocycle-per-second. This enables the EAI 680 to meet the high-speed multiplication requirements usually associated with hybrid, iterative-type problems.

Patch Panel Terminals

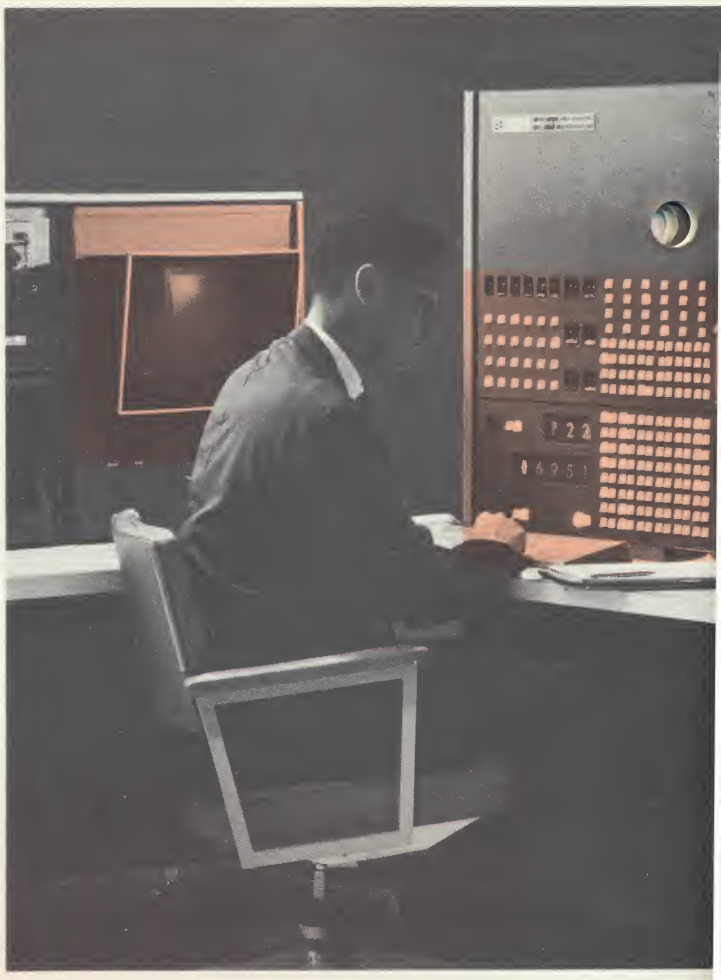
The EAI 680 patch panel provides termination for both digital and analog signals. Terminals are included for control lines, sense lines, trunk lines, and other lines required for hybrid operation. In addition, termination is provided for digital-to-analog and analog-to-digital conversion equipment.

Expansion Facility

The EAI 680 Scientific Computing System is provided with facilities for complete modular expansion of its fully-wired, basic computer console — using a variety of plug-in components. In addition, extensive trunking and slaving facilities enable the combined operation of several EAI 680 consoles as one large system.



A TYPICAL EAI 680 HYBRID COMPUTING SYSTEM



OPERATOR ACCESSIBILITY

Designed specifically to provide engineers and scientists with the capability for solving complex system problems, the EAI 680 Scientific Computing System provides the operator with the ultimate in accessibility and operating convenience. For example — all system controls and readout devices have been made accessible to the operator seated at the console. Special automatic setup features have been included enabling the rapid setting of potentiometers and the verification of their settings. The amount of required control patching — the patching necessary to make a component function in its normal mode — has been reduced to a minimum by the use of normally closed switches on the patch bay contacts. Variable diode function generators have been mounted so that they can be set up by the operator while he is seated at the console. These VDFG components and associated set-up controls are contained in convenient slide out drawers to the operator's right. And — the EAI 680 patch panel has been arranged in modular symmetrical style to facilitate operator familiarity with equipment assignment, component location, patching, and program debugging procedures.

Input-Output Features

A flexible input-output system of the EAI 680 provides complete close communication and control between analog and digital sections and between the operator and the machine — as required for effective hybrid computation. Facilities provided can be expanded to accomplish five basic functions when operating with a stored-program digital computer: selection of analog modes by the digital computer; sensing of analog modes by the digital computer; selection and readout of all addressable analog components; setting of potentiometers by the digital computer; and exchange of data between analog and digital computer components. The analog modes may be selected either manually, by timer control, or by logic program control. The selection and readout of analog components and the setting of potentiometers can be accomplished by the digital computer under direct program control. The types of data and control lines provided with the system include:

DIGITAL LINE TERMINATIONS	ANALOG LINE TERMINATIONS
Digital Trunks	Analog Trunks
A/D Sample Control	ADC Lines
D/A Transfer Control	DAC Lines
Linkage Address Control	Display Lines
Operation Control Lines	Plotter
Interrupt Lines	Recorder
Sense Lines	
Push-Button Lines	
Monitor Scope and Display Control Lines	

The number of lines supplied is sufficient for handling the majority of hybrid problems. However, if required, the number of channels can be expanded for handling unusual and highly complex problems — by special patching.

Extremely fast digital readout of amplifiers and potentiometers is accomplished by using an electronic addressing system. And — facilities are provided for displaying information associated with both high-speed and real-time operation.

COMPUTER CONSOLE AND PATCH PANEL

A compact console of rugged, welded steel frame construction, houses within a single unit, all computing components and facilities for complete programming and control of the EAI 680 Scientific Computing System.

The console's compact size (5′ x 5′ x 2½′) results from the use of modular packaging, solid-state circuitry and high stability components which do not require ovens. The use of solid-state devices rather than vacuum tubes eliminates the need for expensive space-stealing air-conditioning equipment. The reduced power requirements of a 10 volt system enable operation of the computer from any normal electrical wall outlet. Also — with precision low-drift integrating capacitors, no bulky ovens and related temperature control equipment are required.

Human engineering in the design of the console has provided the operator with optimum accessibility to the patch-panel, various controls, indicators and components. The patch panel is located in the upper right-half of the console above an operating shelf containing the machine's control panel. Analog signals are patched to terminals on the patch-panel's bottom four rows designated as the analog section. Logic signals are patched to the top row which serves as the digital section. Clearly identified terminals combined with different patch-cord types and sizes prevent the possibility of inter-patching analog and digital signals. Terminals are provided for external as well as internal digital and analog signals — an important feature for hybrid use.

The analog section of the patch panel has been divided into twelve modules each containing ten plug-in analog trays. The tray positions within each of the twelve modules are very similar. Therefore, it is only necessary for the user to become familiar with the organization of one module in order to understand the entire patch-panel structure.

The trays in the logic section that are normally used in communicating with the analog section are located directly above the corresponding analog trays. This greatly facilitates the location and patching of logic signals for controlling the analog equipment.

The console's analog and digital indicators are mounted on panels located to the left of the patch-panel. The digital indicator and control panel provides complete logic selection and readout — with the state of each storage element and each AND gate indicated. Facilities are provided for the selection and control of potentiometers, address readout and function relays. The overload indicator panel located above the patch-panel provides separate indication of an overload condition in any amplifier, multiplier or variable diode function generator.

The console's control panel, which is mounted on the operating shelf at convenient desk height, consists of three sections — digital control, addressing and analog control. Flexible, multi-level control is made available to the operator — for control of the entire system, for multi-speed control of groups of components and for control of individual components. This control is provided for both mode and time-scale programming. Certain control features that are particularly useful for hybrid computation include: electronic mode control that operates at microsecond speed; logic control of individual integrators — with four time scales available; and, synchronous logic control that can be single-stepped when required to facilitate programming and problem check-out.

Several other important features have been incorporated in the console's advanced design. For example — a significant reduction in cross-talk has been achieved by careful, consistent shielding throughout and assignment of separate areas on the patch panel for analog and digital signals. Wiring and power supplies have been included in the console for plug-in logic expansion of the basic computer. And — internal slaving equipment and controls enable the "on-line" operation of each console as part of a large system or the "off-line" operation of each console for individual problem solution.

COMPUTER COMPONENTS

The outstanding performance of the EAI 680 system is based on its large complement of quality linear and non-linear computer components. These components — mounted in compact removable trays in the console — are characterized by their high-speed operation, low drift and excellent static accuracies (0.01% for linear components).

The system's high-speed operational amplifiers perform at full amplitude over their entire, 500 kc bandwidth, with negligible velocity limiting. These amplifiers are stable for wide values of feedback impedance and output loading. The amplifiers — up to 156 in an expanded system — are used for many different operations. In the combination amplifier form, they may be used as summing amplifiers, integrators, electronic switches or as track/store units.

Integrating amplifiers are provided with individual time scaling using any of four available time scales. A number of integrators can be operated simultaneously at different speeds — a capability which is particularly useful for iterative and hybrid computation. Also useful in this regard, is the integrator's ability to reset very rapidly — from the operating mode to the initial condition mode — in approximately 1 microsecond. The computer integrating capacitors have a negligible temperature coefficient thus eliminating the need for ovens in the computer. Also — these capacitors have been made adjustable to provide the long term drift compensation required for continual operating stability.

Extremely fast signal tracking (in under 1 microsecond) combined with low drift storage is provided by the system's track/store units. The exceptional performance achieved is based on the use of two capacitor sizes in each unit. The tracking operation is performed using a small-size capacitor; a larger capacitor is switched in for the storage function.

The standard component complement of the EAI 680 Scientific Computing System includes 120 potentiometers. These potentiometers can be set manually or automatically as required. When set automatically they are adjusted by a "servo" system at a rate exceeding one potentiometer setting per second. A "Joy Stick" control enables manual adjustment of any potentiometer during computation — a feature that is particularly useful for the model experimentation required in the simulation of physical systems.

The large complement of non-linear, special and digital components includes electronic quarter-square multipliers, diode function generators, resolvers, comparators, limiters and logic components. The type of high-speed electronic multiplier used provides exceptional computation accuracy. Available for use with each multiplier is an uncommitted output amplifier mounted in the same console tray.

Among the other components in the console are variable hard limiters of the feedback type and hard zero limiters. The logic components included are general purpose registers, flip-flops, AND gates, BCD counters, monostable units and differentiators.

All of the components have terminals for their interconnection on the patch-panel. The amount and type of components available in an expanded EAI 680 system is summarized below:

Analog Equipment

Amplifiers	156
Variable Diode Function Generators (10 segment)	18
Multipliers (Quarter-Square)	24
Pots (Servo-Set)	120
Pots (Hand-Set)	12
Combination Amplifiers (Integrator/Summer)	30
Sin/Cosine DFG's	12
Log DFG's	6
Feedback Limiters	12
Hard Zero Limiters	12
Loose Diodes	36
Loose Resistors	
Gain 1 (100k)	48
Gain 10 (10k)	36
Gain 100 (1k)	6

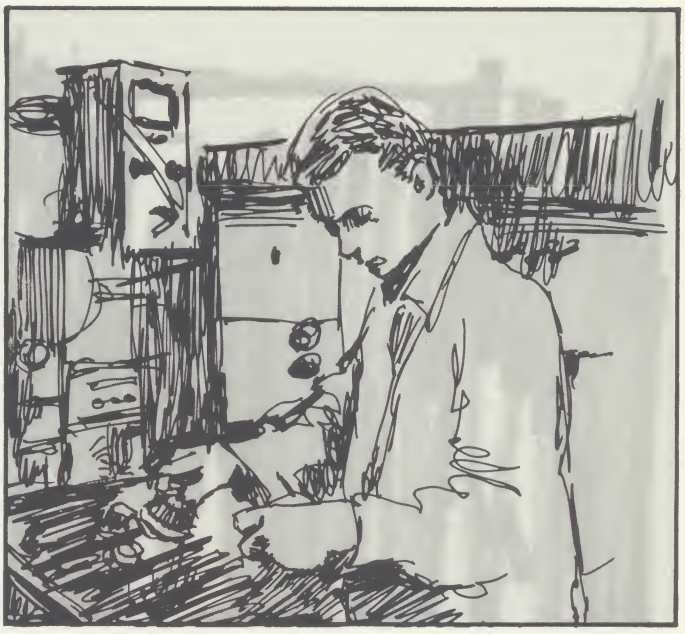
Logic and Interface Equipment

Electronic Comparators	24
D/A Electronic Switches	24
D/A Relay (DPDT)	24
Track/Store Units	12
Four-Bit General Purpose Registers	6
AND Gates	42
Monostable Timers (One-Shots, or Pulsers)	6
Differentiators	6
BCD Counters (2-Decade, Bi-Directional)	3

Amplifier Complement

The complement of 156 amplifiers includes the following:

Combination Amplifier (may be used as integrator, summer, or high-gain amplifier)	30
Summer (may also be used as high-gain amplifier)	24
Inverter/High-Gain Amplifier (may be used as inverter or as output amplifier for non-linear equipment; may also be used as multi-input summer by patching additional resistors to amplifier junction)	42
Output Amplifier for Quarter-Square Multiplier (may be separated from its associated multiplier, allowing independent use of multiplier and amplifier)	24
Amplifiers Associated with Variable Diode Function Generators (when DFG not in use, the output amplifier is available as an inverter)	36
Total	156



SYSTEM SUPPORT

The EAI 680 Scientific Computing System is supported by many years of experience in hybrid computation. In addition, a hybrid software library that contains programs and subroutines for various phases of hybrid simulation will soon be available. Included will be typical hybrid problem solutions to aid the programmer in problem analysis and simplification, programming, problem check-out and problem documentation.

In addition to extensive software support, the EAI 680 system has the support of a world-wide field service organization. This is the only service organization in the computer industry, that is trained to service all types of scientific computing systems — analog, digital, and hybrid. The organization operates in conjunction with equipment repair and part support functions.

Other support is provided by an extensive training and education facility. Comprehensive training courses at EAI Computation Centers are made available — free of charge — to every EAI 680 user. Also available is an applications reference library — the world's largest — containing hundreds of analog and hybrid studies, that have been compiled over a period of several years.

Rounding out this extensive support program for the EAI 680 system are EAI Computation Centers located throughout the world. These centers — completely equipped with the latest scientific computing equipment — are available to the customer for his use. The EAI applications staff is available for consultation on programming, operation and maintenance.

EAI®

ELECTRONIC ASSOCIATES, INC. *West Long Branch, New Jersey*

ADVANCED SYSTEMS ANALYSIS AND COMPUTATION SERVICES/ANALOG COMPUTERS/DIGITAL COMPUTERS/HYBRID ANALOG-DIGITAL COMPUTATION EQUIPMENT/ANALOG AND DIGITAL PLOTTERS/SIMULATION SYSTEMS/SCIENTIFIC AND LABORATORY INSTRUMENTS/INDUSTRIAL PROCESS CONTROL SYSTEMS/PHOTOGRAMMETRIC EQUIPMENT/RANGE INSTRUMENTATION SYSTEMS/TEST AND CHECK-OUT SYSTEMS/MILITARY AND INDUSTRIAL RESEARCH AND DEVELOPMENT SERVICES/FIELD ENGINEERING AND EQUIPMENT MAINTENANCE SERVICES.

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